APPENDIX A SLAB REPLACEMENT CHECKLIST

Slab and treated base replacement

PRE-CONSTRUCTION

- ☐ Review Plans, Specifications and Special Provisions for special information, completeness, and accuracy
- ☐ Prepare yourself and your staff for night work, if necessary
- ☐ Kick-off meeting with designer (Pre-Job Meeting)
  - ⇒ Clarify design intent
  - ⇒ Clarify location of slabs to be replaced
  - ⇒ Clarify plans and specifications
  - ⇒ Lessons learned from past experiences
- ☐ Material testing
  - ⇒ Review Standard Specifications
  - ⇒ Review Special Provisions
  - ⇒ Prepare to sample and test beams
  - ⇒ Ensure that testing staff is certified to perform the required testing
  - ⇒ Submit samples of cement and admixtures to METS for testing
  - ⇒ Submit sample aggregate source for testing by District Lab
  - ⇒ Review contractor's quality control plan, if specified
- ☐ Plant inspection
  - ⇒ Review Special Provisions, weightmaster certificates, material stockpiles, control room operations
  - ⇒ Batch or volumetric mixing requirements, general requirements of the cement, proportioning, and weight certificates
  - ⇒ Check for proper plant certification (CT 109)
  - ⇒ Mix design
  - ⇒ Prepare to provide plant inspection services
- ☐ Notify field laboratory for them to provide plant inspection service
- ☐ Create list of Submittals (CEM-3101)
- ☐ Project awarded–request for mix design and samples that need to be sent to Translab
- ☐ Schedule Just In-Time Training (JITT), prepare CCO if necessary
- ☐ Review Contingency Plans
  - ⇒ What to do when things go wrong
  - ⇒ Plant or equipment breakdown
  - ⇒ Modulus of rupture does not meet requirements for opening to traffic

- ☐ Set up trial slab for each mix design
- ☐ Before the start of each work week:
  - ⇒ Plant inspection request: sample cement for shipping to Translab, test aggregate for gradation and cleanness value (CV)
  - ⇒ Strength testing request: modulus of rupture, flexural beams
  - ⇒ Review contractor's proposed washout pit

DETERMINE EXACT LIMITS OF CONCRETE PAVEMENT REMOVAL

- ☐ Engineer must locate and number slabs to be removed
- ☐ Review cross sections and quantity charts in the plans to narrow down the freeway section
- ☐ Walk the freeway with the contractor, as a courtesy ask the designer and local maintenance supervisor to come along
- ☐ Look for third-stage cracking, faulting, spalling, and corner cracking
- ☐ Prepare a slab replacement log
  - ⇒ Show location and dimension of slabs to be replaced
  - ⇒ Before pre-sawing begins match the quantities of concrete to be removed on the plans with the estimate from the field review
  - ⇒ Include a column on the slab replacement log if the contract has separate pay items for dowels and/or tie bars that are placed in the slabs

PRE-SAWING SLABS

- ☐ Engineering judgment must be used when planning to pre-cut concrete slabs
  - ⇒ Review the existing condition of the slabs to determine whether the pre-cut slab will hold up under traffic until it is replaced
  - ⇒ Avoid keeping the pre-cut area open to traffic for more than 2 days, as this will cause more pavement deterioration
- ☐ Slabs may have to be cut on the night they are replaced
- ☐ Exercise caution if large traces of crack sealant are evident on the surface of the existing slabs
- ☐ Outline of concrete to be removed should be sawed full depth with a power-driven saw
- ☐ Remove the concrete in rectangular sections to simplify concrete removal
- ☐ Do not make notches or diagonal cuts in the pavement
- ☐ Water residue from concrete cutting should be vacuumed immediately

CONCRETE PAVEMENT REMOVAL

- ☐ Pavement removal should be performed without damage to pavement that is to remain in place
- ☐ Any damage to pavement that is to remain in place should be repaired to a condition satisfactory to the engineer, or the damaged pavement should be removed and replaced with new concrete pavement if ordered by the engineer

Non-impact (Liftout) Method

- ☐ Each slab should be removed in one or more sections without disturbance or damage to the underlying base or the surrounding pavement that remains in place
- ☐ Slabs can be pre-sawed prior to the night of removal and replace
- ☐ DO NOT allow the contractor to drop concrete onto the existing base when lifting out

Impact (Break-up) Method

- ☐ Caltrans does not approve any impact slab removal techniques, except for use in removal of full-depth and treated base.

Possible Problems During Removal

- ☐ Engineer determines that existing base is not suitable
  - ⇒ Base should be removed and replaced to the same thickness with new base material and covered with a bond-breaking material prior to construction of the replacement pavement; new base material should be fast-setting cement conforming to the provision of "Concrete Replacement Pavement"

⇒ Removal and replacement of unsuitable base material and bond breaking material will be paid as extra work, as provided in Section 4-1.03D, "Extra Work," of the Standard Specifications

- ☐ Slab is thicker than shown on the plans and pre-sawing did not reach full depth
- ☐ Water is present under the slab when concrete is removed
- ☐ Slabs shatter when lifted
- ☐ Lift pins fail to hold PCC pavement section

SLAB PREPARATION

- ☐ Contractor must provide adequate lighting

Dowel Baskets, Transverse Dowels & Tie Bars (Load Transferring Devices):

- ☐ Review Construction Details and Standard Plans to determine if dowel baskets, transverse dowels, or tie bars are required; if load-transferring devices are required, determine the spacing, depth of hole, and size of devices (Special Provisions, Project Plans, Standard Plans, and Standard Specifications)
- ☐ Headquarters (HQ) recommendations for the use of load transferring devices:
- ☐ Dowel baskets are required when replacing two or more slabs in a row on freeways carrying more than a low volume of heavy trucks
- ☐ Transverse dowels are required between new and existing slabs
- ☐ Tie bars are required if there is an unstabilized base or if placed in a region that experiences freeze-thaw cycles or receives 130+ cm of rain per year

Dowel Holes

- ☐ Dowel holes should be drilled by methods that will not shatter or damage the concrete adjacent to the holes
- ☐ Layout and depth of dowels need to be inspected
- ☐ Dowel holes should be cleaned/blown out prior to placing the epoxy

Bond Breaker

- ☐ Suitable plastic sheeting, 15 mils thick, should be placed between the replacement pavement and the base for full-depth repairs; for full-depth and treated base repairs, Suitable plastic sheeting should be placed on the subgrade or subbase layer immediately prior to concrete placement

DOWEL INSTALLATION

Transverse Contact Joints

- ☐ Expansion caps must be placed on the exposed end if a non-shrink mix is used
- ☐ Place parallel to the lane lines at a depth equal to t/2
- ☐ Bonding of the embedded dowel is necessary for effective load transfer

Weakened Plane Joints

- ☐ Dowels should be placed at all weakened joints within a slab repair using type A or U baskets; type J baskets do not meet the Caltrans loading requirements
- ☐ Baskets must begin at the existing pavement joint, such as the adjacent passing lane joint
  - ⇒ The joint in the new weakened plane joint should be installed perpendicular to lane lines in all situations
  - ⇒ If the joint was previously skewed, it will still be placed perpendicular to lane lines, eliminating skew within the replaced slab section.
- ☐ Each basket must be anchored securely with approved concrete fasteners (for a 3.65-m wide slab) and constructed to hold all dowels firmly at a depth of t/2 and maintain alignment
- ☐ Expansion caps are needed on retrofitted dowel bars.
- ☐ Once the dowels are placed and prior to concrete placement, watch for any signs of misalignment during the concrete placement; misalignment of the dowels will lead to increased stress within the new concrete pavement and result in premature cracking and failure of the repaired pavement section.

EXPANSION MATERIAL PLACEMENT

Transverse Contact Joints

- ☐ A 6-mm-thick foam expansion material must be placed securely across the transverse joint face and extend the full depth of the joint, with the top of the expansion material flush with the top of the pavement
- ☐ Expansion material must be cut to fit with holes for drill-and-bond dowels
- ☐ The expansion material should be secured to the face of the existing pavement joint by any method that will hold the expansion material securely in place during concrete placement; concrete should not be allowed to get between the expansion material and existing PCC pavement

Longitudinal Contact Joints

- ☐ Expansion materials are not required along the longitudinal contract joint for isolated pavement slab repairs
- ☐ Expansion materials may be placed along longitudinal contact joints if the adjacent pavement slabs are scheduled for replacement; use of the expansion materials prevents bonding at the longitudinal joint and will reduce slab removal and replacement times
- ☐ If expansion material is used along longitudinal contact joints, it must be placed securely across the entire length of the joint and extend the full depth, with the top of the expansion material flush with the top of the pavement joint
- ☐ The expansion materials along the longitudinal joint face must be removed when the adjacent slab is removed and replaced

CONCRETE PLACEMENT

- ☐ Ensure that slab preparation has been inspected and the contractor is permitted to place concrete

Concrete Arrives On-site

- ☐ Verify dowel alignment during placement
- ☐ Check temperature
- ☐ Watch for consistency of concrete
  - ⇒ How long is the material workable?
  - ⇒ How much slump does it have?
  - ⇒ Other properties
- ☐ Watch for cement balls coming down the chute
- ☐ Ensure that the vibrator is keeping up with the concrete placement, especially around load transferring devices if necessary add vibrators
- ☐ Ensure that final finishing is keeping up with concrete placement, workability, surface retardant to help with finish of the concrete surface.

CONCRETE TESTING

- ☐ Concrete testing requirements are contract-specific. Some contracts require Caltrans to do the testing, whereas others require the contractor to make the arrangements
- ☐ Support Caltrans Material Tester with sampling.
- ☐ Make arrangements with testing personnel to get the test results to the Inspector, who will reopen the freeway

AFTER PLACEMENT

Curing Concrete Slabs

- ☐ Curing compound should be applied as recommended by the manufacturer of the cement and approved by the engineer in writing
- ☐ Slabs should be covered with insulating blanket
- ☐ Curing should occur in a timely manner

Protecting Newly Placed Slabs

- ☐ Completed slabs must be protected so that vehicles will not drive on them
- ☐ Contractor should have "WET CONCRETE" signs on barricades, it is recommended to place cones around the entire perimeter of the replaced slabs
- ☐ Do not place the barricades or cones on the newly placed slabs, as this will damage the surface finish

Weakened Plane Joints

- ☐ Transverse weakened plane joints in the replaced pavement should be constructed perpendicular to the direction of lane lines
- ☐ Sawing of weakened plane joints should commence as soon as the concrete will support the saw (refer to Caltrans Specification 40-1.08 B (1))
- ☐ The minimum depth of the cut for the weakened plane joint should be t/3, where t is the slab depth

Clean-up & Opening to Traffic

- ☐ Recommend a street sweeper
- ☐ Refresh pavement delineation, markers, and stripes
- ☐ Open freeway lanes to traffic when passing modulus of rupture test results are reported
- ☐ Concrete quantity should be agreed upon between the State and the contractor
- ☐ Quantity is based on actual measurements, not quantity on concrete tickets

GRINDING AND JOINT SEALING

Grinding and joint sealing adds life to the existing roadway by accomplishing the following:

- ☐ Remove transverse joint and crack faulting (principal function)
- ☐ Improve transverse slope
- ☐ Improve ride quality by removing faulting, surface roughness, and unevenness caused by slab replacement
- ☐ Reduce unwanted noise and provide a safe, long-lasting surface texture

Criteria for Grinding

- ☐ Faulting greater than 2.6 mm
- ☐ Most effective way is to grind an entire lane width of the roadway

Joint Sealing

- ☐ Are sawed joints established?
- ☐ Clean by water cleaning and air blasting

Sealant Installation

- ☐ Place backer rod, then place sealant
- ☐ Silicone joint sealant is to be used for all transverse and longitudinal joints when specified

MISCELLANEOUS PROBLEMS

- ☐ Test beams do not meet minimum requirements
  Headquarters (HQ) recommends an OPENING TO TRAFFIC MINIMUM OF 2.4 MPa
- ☐ Engineering decision must be made if the required strength for opening is not achieved
- ☐ Contingency plans:
  - ⇒ Physically test pavement–bang with hammer, drive vehicle on it
  - ⇒ Look at the volume of traffic and buy as much time as possible; open lanes that do not need to be closed

POTENTIAL ISSUES

COLD JOINTS

- ☐ To determine if a cold joint exists, physically test the portion of concrete in place before finishing the slab–methods of testing can include hitting the concrete with a hammer, poking the concrete with a piece of rebar or standing on the concrete
- ☐ Notifying contractor's representative that a cold joint exists, and paint a reference mark on the adjacent pavement so the cold joint can be located at a later date
- ☐ Slabs may be rejected as a result of cold joints
- ☐ Key inspection items:
  - ⇒ Frequency of trucks – enough trucks must be available to deliver concrete continuously to the job site within the concrete setting time
  - ⇒ Concrete setting time
  - ⇒ Concrete temperature when discharging from ready mix truck
- ☐ Loads of concrete may be sent away by the contractor because the concrete is too hot before unloading begins; this can trigger a chain reaction for problems the rest of the shift

CONCRETE SLUMP

Low Slump

- ☐ Low slump can cause loads of concrete to be sent back/rejected
- ☐ Concrete should be delivered to the job with a slump within the approved mix design; the average is 102 to 204 mm
- ☐ Additional water (added to the surface of the concrete) should not be used because it causes problems with workability and surface finish

High Slump

- ☐ May be caused by a variety of factors
  - ⇒ Truck drivers leaving wash water in the drums of the concrete trucks
  - ⇒ Kelly ball does not measure these high slumps
- ☐ Address immediately with the grade quality control (QC) person
- ☐ Paint a reference point on adjacent pavement where you feel high slump concrete was incorporated and monitor for possible failure

CRACKING

- ☐ Thermal cracking may occur in slabs placed when the temperature hovers around 5°C; cover slabs with insulation blanket when the temperature fall below 13°C
- ☐ High slump concrete can cause cracking
  - ⇒ Surface cracks
  - ⇒ Large transverse shrinkage cracks

CLEANNESS VALUE FAILURE OF THE AGGREGATE

- ☐ If the CV is out of operating range or out of contract compliance, take corrective actions at the batch plant before the work is allowed to resume
- ☐ In accordance with Section 90-2.02 of the Standard Specifications, the State will take a deduction of $4.60 per m^3 for all concrete out of contract compliance

STRENGTH

- ☐ If 4-hour or 7-day strengths do not reach the required flexural strength, adjust pay in accordance with the contract specifications
- ☐ Test results should be graphed to look for trends in overall performance and consistency of the concrete

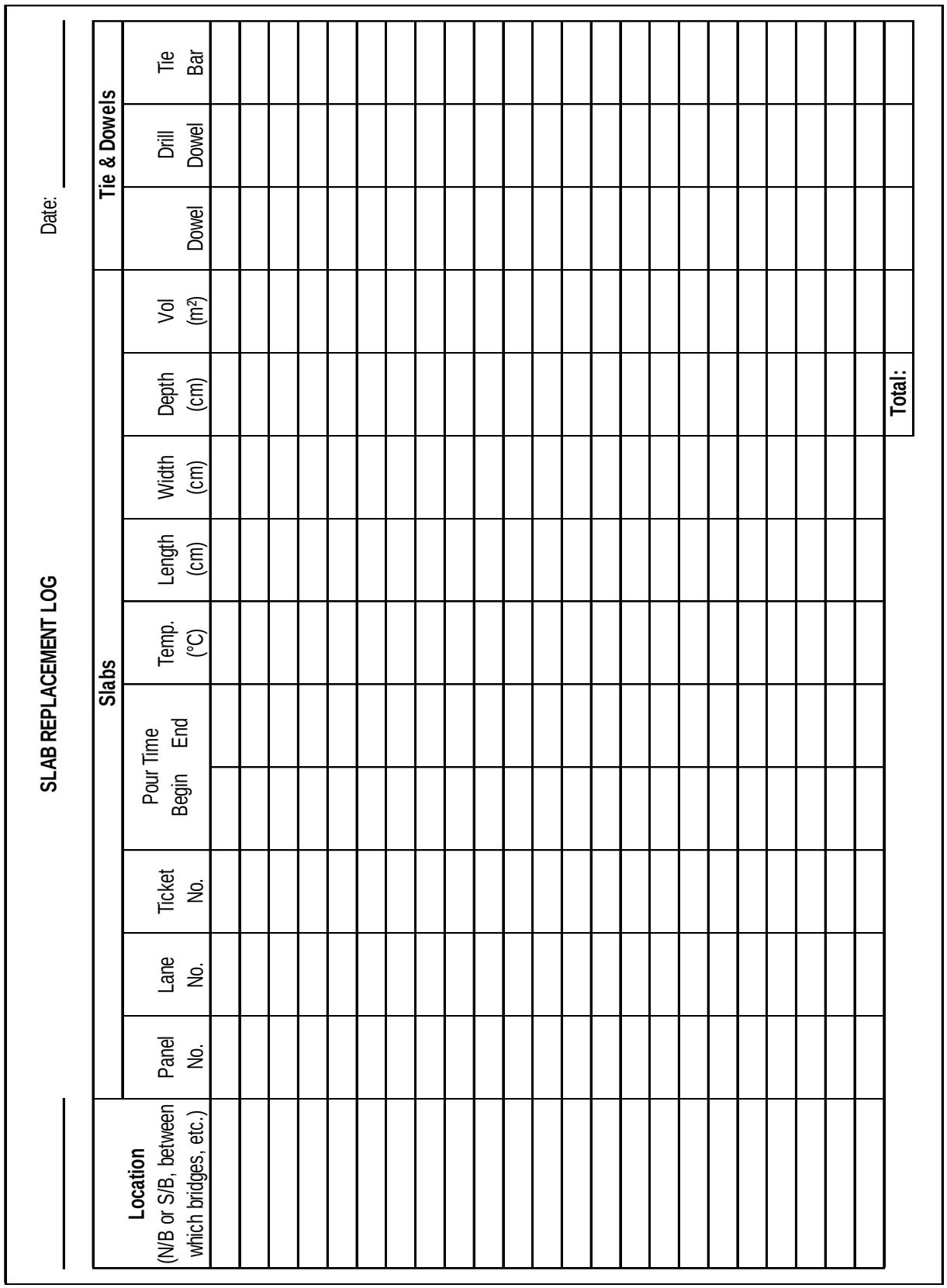
SAMPLING & TESTING

- ☐ At least 45 days prior to intended use, the contractor should furnish a sample of the fast-setting hydraulic cement from each lot proposed for use and all admixtures proposed for use in the quantities ordered by the engineer
- ☐ Identify the lot number of material
- ☐ Identify foreign material sources
- ☐ Samples of all components of the mix should be sent to Translab at the beginning of the job and when possible problems are detected; it is required to take random samples during the contract per Section 8 of the Construction Manual

MISCELLANEOUS

- ☐ Consistency of concrete should be noted from one batch to the next
- ☐ Temperature is critical for all components
  - ⇒ Cement
  - ⇒ Aggregate
  - ⇒ Water
  - ⇒ Admixtures
  - ⇒ Ambient air
- ☐ Ready mix concrete should be delivered by experienced drivers with specific instructions for cleaning trucks and transporting, drivers should attend JITT
- ☐ Placement methods
- ☐ Mix design criteria

SLAB REPLACEMENT LOG



SLAB REPLACEMENT MAP

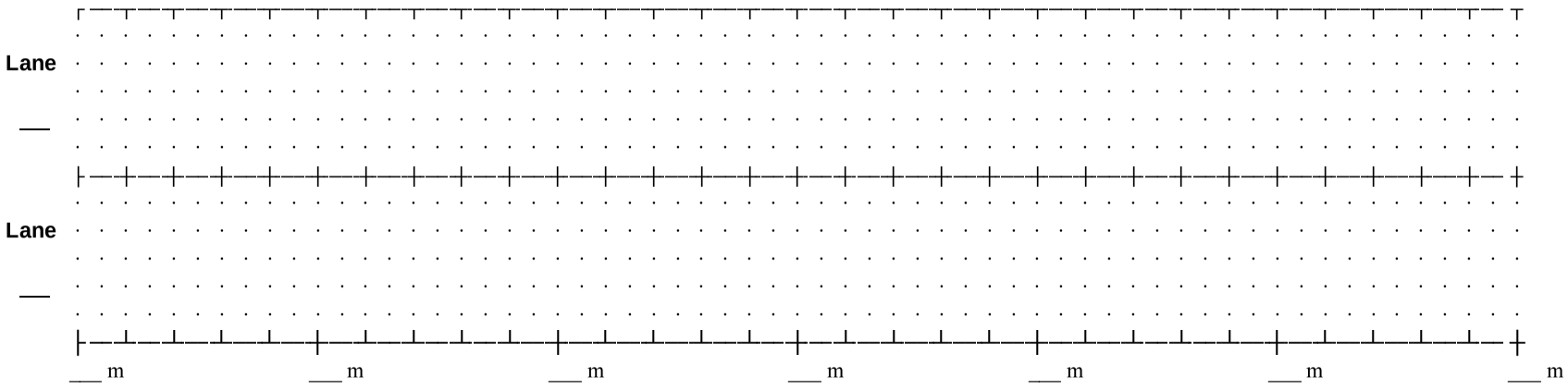
Direction: ______									Direction: ______							CO-RTE-PM:____________
	Lane								Lane							
	S	4	3	2	1	H	S	CENTER DIVIDER	S	H	1	2	3	4	S	Notes

S = Shoulder H = HOV Lane

DISTRESS MAP

CO-RTE-PM: _____ Direction: _____ Page: _____

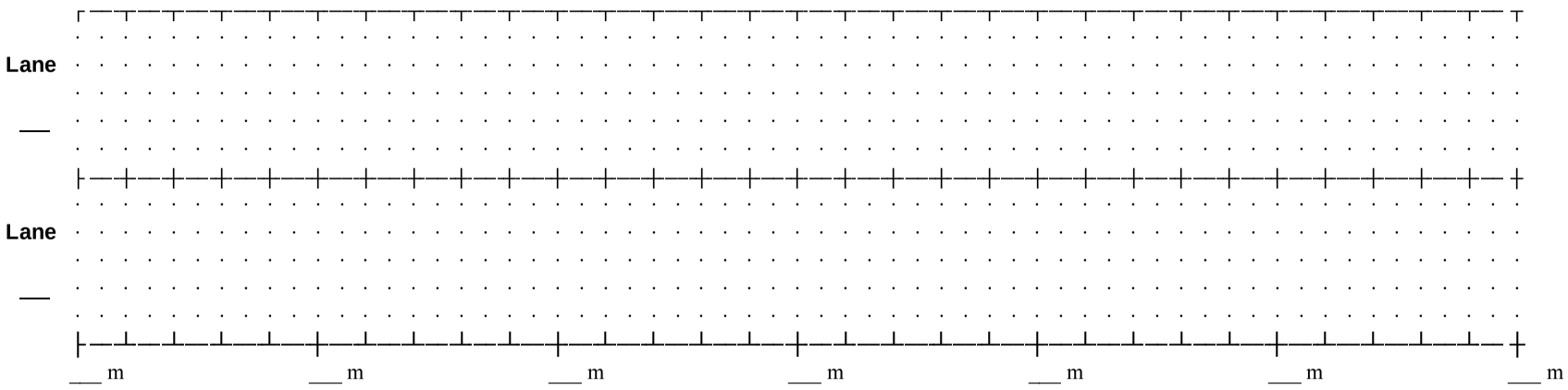
Panel No.: Date: _____



Comments: _____

_____

Panel No.:



Comments: _____

_____

FIELD DATA SUMMARY FORM

CO-RTE-PM: _____ **Date:** _____

Direction: _____

Lane	Panel No.	Cracking		Faulting	Pumping	Other	Photo	Comment
		Type	Severity	mm	(y/n)	Distress	no.	

Cracking type:

TC = transverse; LC = longitudinal; CB = corner break

SS = Stage 3 (shattered slab with intersecting cracks)

Other distress type: ASR = Alkali-silica reactivity; R = Wheepath rutting

Distress severity: transverse cracking

	Low (L)	Medium (M)	High (H)
Crack width (mm)	< 3 mm	≥ 3 mm; < 6 mm	≥ 6 mm
Faulting (mm)	< 2 mm	≥ 2 mm; < 6 mm	≥ 6 mm
Spall width (mm)	none	< 75 mm	≥ 75 mm

Distress severity: longitudinal cracking and corner breaks

	Low (L)	Medium (M)	High (H)
Crack width (mm)	< 3 mm	≥ 3 mm; < 13 mm	≥ 13 mm
Faulting (mm)	< 2 mm	≥ 2 mm; < 13 mm	≥ 13 mm
Spall width (mm)	none	< 75 mm	≥ 75 mm

SLAB REPLACEMENT SUMMARY FORM

CO-RTE-PM: _____ **Date:** _____

Direction: _____

Lane	Panel No.	Cracking Type	Cracking Severity	Faulting mm	Pumping (y/n)	Material Distress	Replace (y/n) Slab	Replace (y/n) Base	Repair size, m Width	Repair size, m Length	Tie bar (y/n)	Dowel (y/n)	Jt. Seal (y/n)	Grind (y/n)	Photo no.	Comment

Cracking type:
TC= transverse; LC = longitudinal; CB = corner break
SC = Stage 3 (shattered slab with intersecting cracks)
Other distress type: ASR = Alkali-silica reactivity
R = Wheelpath rutting

Distress severity:

	Transverse Crack			Longitdinal Crack & CB		
	Low(L)	Med.(M)	High(H)	Low(L)	Med.(M)	High(H)
Crack width, mm	<3	≥3; <6	≥6	<3	≥3; <13	≥13
Faulting, mm	<2	≥2; <6	≥6	<2	≥2; <13	≥13
Spall width, mm	none	<75	≥75	none	<75	≥75

NOTES

APPENDIX B SUMMARY OF MATERIAL TESTING PROCEDURES

Concrete thermometer

Concrete testing should be performed according to established procedures, as defined by ASTM, ACI, and appropriate California Test Methods. The following provides a brief summary of the testing procedures.

TEMPERATURE TEST (ASTM C 1064)

The temperature measuring device should be capable of measuring the temperature to within ± 0.5°C throughout the range likely to be encountered. The device should conform to the requirements for ASTM thermometer No. 36 C as prescribed in List B of ASTM E 1 or another of equal accuracy.

The temperature of the freshly mixed concrete may be taken in the transporting equipment before concrete placement in the forms, or if the sample is prepared properly, in a container following concrete placement. No matter what container is used, be sure that the sensor of the temperature measuring device has at least 75 mm of concrete surrounding it.

Gently place concrete around the temperature measuring device so that the ambient air temperature does not come into direct contact with the sensing area of the device, as this may affect the accuracy of the reading.

Leave the temperature measuring device in the freshly mixed concrete for a minimum of 2 minutes or until the temperature reading stabilizes. Then read and record the temperature of the freshly mixed concrete to the nearest 0.5°C. Complete the temperature measuring of the freshly mixed concrete within 5 minutes after obtaining the sample.

For compliance with specifications, measure the temperature of the concrete sample obtained in accordance with ASTM C 172.

SAMPLING FRESHLY MIXED CONCRETE (CT 539)

CT 539 supersedes ASTM C172.

Secure a composite sample from the middle portion of the batch as soon as possible, but in no instance should the elapsed time between obtaining the first and final portions exceed 15 minutes. Sampling can occur at the following locations:

- **Stationary mixers**: Sample the concrete at two or more regularly spaced intervals during discharge of the middle portion of the batch.
- **Paving mixers**: Sample the concrete after the contents of the paving mixer have been discharged. Obtain samples from at least five different areas of the material pile, and then combine them into one composite sample for test purposes.
- **Revolving drum truck mixer or agitators**: Sample the concrete at two or more regularly spaced intervals during discharge of middle portion of the batch.
- **Open-top trucks** (mixers, agitators, non-agitating equipment, or other types of open-top containers): Take samples using whichever procedure previously described is most applicable.

If possible, transport the sample to the location where testing will occur and specimens are to be stored.

The minimum size of sample to be used for strength tests should be 28 liters.

Combine and remix the sample.

Sample preparation:

- Begin tests for slump or air content, or both, within 5 minutes after the sampling is completed.
- Begin molding specimens for strength tests within 15 minutes after fabricating the composite sample.
- Cover sample to protect from drying.

DENSITY OF FRESH CONCRETE (CT 518)

- Determine the tare weight of the calibrated container. A 14-liter bucket is generally used for better accuracy when the concrete contains nominal 19- to 38-mm coarse aggregate.
- Remix the concrete sample, moisten the equipment, and then remove excess water.
- Fill the unit weight container in three equal layers, rodding each layer 25 times.

When rodding:

- Do not strike the bottom of the container when rodding the first lift.
- Penetrate approximately 25 mm into the previous layer.
- Tap on the sides of the container smartly 10 to 15 times with the appropriate mallet (0.568 ± 0.23 kg for measures of 14 liters or smaller) after rodding each layer.
- Vibrate the concrete when the slump is less than 25 mm. Rod or vibrate when the slump is 25 to 75 mm. Rod for slumps over 75 mm.

- .There should be no substantial excess or shortage of concrete after consolidation. An excess of 3 mm is optimum. Small quantities of material can be added or removed with a scoop or trowel.
- Strike off the concrete surface by covering two-thirds of the surface with a flat 6-mm-thick metal or 13-mm-thick glass or acrylic strike-off plate. Apply downward pressure and withdraw the plate with a swinging motion to finish the original area covered.
- Cover the original two-thirds and advance the whole plate with downward pressure and a sawing motion completely across the concrete surface. Screed the surface with the inclined edge of the plate.
- Clean the sides and bottom of the container.
- Weigh the container and calculate the unit weight of the material.

AIR CONTENT OF FRESHLY MIXED CONCRETE

The air content of freshly mixed concrete can be measured using either the pressure or volumetric method. Both test methods are discussed below.

Determining Air Content of Freshly Mixed Concrete by the Pressure Method (CT 504)

- This test method is not for concrete containing lightweight or porous aggregate.
- Determine the aggregate correction factor (see ASTM C 231, paragraph 5). Remix the sample and moisten the meter.
- Moisten the equipment and then remove any excess water.

- Fill the bowl in three equal layers, uniformly rodding each layer 25 times, and penetrating 25 mm into the previous layer. Do not impact the bottom of the container while rodding the first lift. Tap the sides smartly 10 to 15 times with a standard mallet after rodding each layer. There should be no substantial excess or shortage of concrete after consolidation. An excess of 3 mm is optimum.
- Strike off excess material with a metal strike-off bar using a sawing motion. Clean the contact surfaces and dampen the rubber seal on the cover.
- Open both petcocks and clamp on the cover.
- Close the main air valve between the air chamber and the measuring bowl.
- Syringe water into one petcock until water comes out the other petcock.
- Jar the meter gently until no air bubbles come out.
- Close the air bleeder valve and pump the pressure up to the initial pressure line, as indicated on the meter (usually 2 to 3%, depending on calibration).
- Allow a few seconds for compressed air to cool and then zero the meter at the pressure line by pumping or bleeding while tapping the gauge lightly.
- Close both petcock holes on the cover.
- Open the main air valve. Sharply tap the base with a mallet and lightly tap the gauge with the hand.
- Read the air content on the gauge and subtract the aggregate correction factor.
- Release the pressure by opening both petcocks.

Determining Air Content of Freshly Mixed Concrete by the Volumetric Method (CT 543)

- Remix the concrete sample.
- Dampen the bowl and then remove excess moisture.
- Fill the bowl with concrete in three equal layers.
- Uniformly rod each layer 25 times, penetrating the previous layer approximately 15 mm. Do not impact the bottom of the bowl when rodding the first lift.
- Tap on the sides of the bowl smartly 10 to 15 times after rodding each layer.
- Strike off the excess material of the top layer with a strike-off bar using a sawing motion.
- Wipe the contact surface clean.
- Clamp the top to the base.
- Fill with water using a funnel. Remove the funnel and adjust water level to the zero mark using a syringe.
- Invert the meter and agitate until the concrete settles away from the bowl.
- Roll the meter on its flange with the neck slightly elevated for approximately 2 minutes.
- Set the meter upright, jar it lightly and wait until the air rises to the top.
- Repeat the rolling operation until no further drop in the water column is observed.
- Dispel the foam with standard measuring cups of 70% isopropyl alcohol. (It may be necessary to roll the meter several times to verify that there is no further drop in the water column.)
- The air content reading is taken at the bottom of the meniscus in the neck (estimated to the nearest 0.25%) plus the number of cups of alcohol added.

CASTING OF TEST CYLINDERS AND BEAMS

- CTM 540–Making, Handling, and Storing Concrete Compressive Test Specimens in the Field
- CTM 521–Compressive Strength of Molded Concrete Cylinders
- CTM 523–Flexural Strength of Concrete (Using Simple Beam Center-Point Loading, or Third-Point Loading)

Compressive Strength Cylinders

Note: Cylinders are shown for information only. Caltrans does not use cylinders to test strength of pavement.

- Remix the concrete sample.
- Moisten the equipment and then remove excess water.
- Fill standard 152 by 305 mm test cylinders in three equal layers.
- Distribute the concrete evenly, both when filling and when tamping, prior to consolidation.
- Rod each layer 25 times, penetrating the previous layer about 25 mm. Do not impact the bottom of the mold when rodding the first lift. Distribute the strokes uniformly over the cross section of the mold.
- After each layer is rodded, tap the outside of the mold lightly 10 to 15 times to close any holes left by rodding, and to release any large air bubbles that may have been trapped. An open hand may be used to tap light-gauge, single-use cylinder molds.

- Strike the top off with a tamping rod and float or trowel the surface.
- Clean the cylinder exterior. Mark test identification on mold.
- Cover to prevent loss of moisture.
- Initial cure for the first 24 hours must be at 16 to 27°C. Protect the sample from excess heat or cold.
- Final curing requires the concrete cylinder to be in a moist condition at 23 ± 1.7°C until the moment of testing.

Flexural Strength Beams- 1/3 Point Loading (CT 523)

- Remix the concrete sample.
- Moisten the equipment and then remove excess water.
- Fill the standard 152 by 152 by 508 mm beam mold. This mold is used for concrete with nominal maximum-sized coarse aggregate up to 50 mm in two equal layers.
- Distribute the concrete evenly within the mold, both when filling and when tamping, prior to consolidation.

Rodding: Rod each layer once for each 1300 mm^2 of top surface area of the specimen. Distribute the strokes uniformly over the cross-section of the mold. Rod the bottom layer throughout its depth. When rodding the upper layer, allow the rod to penetrate about 15 mm into the underlying layer when the layer is less than 100 mm deep. Penetrate 25 mm when the layer is 100 mm deep or more.

Vibration: After each layer is vibrated, tap the outside of the mold to close any holes left by vibrating, and to release any large air bubbles that may have been trapped.

- After each layer is rodded, spade the concrete along the sides and end of the beam molds with a trowel or other suitable tool.
- When placing the final layer, avoid opverfilling the mold by more than 5 mm.
- Strike off the surface of the concrete and float or trowel as required. Perform all finishing with the least manipulation necessary to produce a flat, even surface that is level with the edge or rim of the mold.
- Cover the specimens immediately after finishing to prevent moisture loss.
- The 24-hour initial cure must be moist at 23 ± 1.7°C until the moment of the test.

RECOMMENDATION FOR RSC:

- Consider plastic molds to retard heat loss.
- Perform flexural strength testing as soon as needed for opening slab to traffic

BALL PENETRATION TEST IN FRESH PORTLAND CEMENT CONCRETE (CT 533)

The ball penetration apparatus consist of a 152-mm cylinder (the "Kelley Ball") with a hemispherical bottom that is machined to a smooth finish.

- The test may be made on concrete in a wheelbarrow, buggy, other container, or after the concrete has been deposited. The concrete depth shall be at least 150 mm for 25-mm or smaller maximum size aggregate. Use 200 mm depth for larger aggregate.
- Strike off the concrete surface over an area of about 0.30 m². Do not tamp, vibrate, or consolidate the concrete. Screed the minimum amount required to obtain a reasonable level surface. Overworking may flush excess mortar to the surface and cause erroneously high penetration readings.
- Hold the device by the handle and lower it slowly over the prepared area until the feet of the yoke touch the concrete surface. Make certain that the shaft is vertical and free to slide through the yoke. Gradually lower the ball onto the concrete, maintaining enough restraint on the handle so that penetration is due to the dead load of the ball only and not to any force generated by acceleration of the mass.
- When the ball comes to a rest, release the handle and read the penetration to the nearest 5 mm. Penetration of the feet of more than 3 mm may indicate that the concrete has been overworked, or that the yoke is binding on the shaft.
- Take a minimum of three readings for each penetration determination. Individual readings shall be at least 250 mm between centers. The minimum horizontal distance from the centerline of the handle to the nearest edge of the level surface on which the test is made shall be 150 mm.
- Report the average of the first three successive readings that agree within 15 mm of penetration.

The amount of water used in concrete mix shall be regulated so that the consistency of the concrete as determined by the penetration test (CT533) is within the following range:

- Nominal penetration: 0 to 25 mm
- Maximum penetration: 40 mm

When Type F or Type G chemical admixtures are used, the measurements must be taken prior to the addition of those admixtures.

NOTES

APPENDIX C EMERGENCY SLAB REPLACEMENT

Occasionally, a situation may require immediate unscheduled repair due to premature pavement failures, blow-ups, or excessive reflective cracking in a crack and seat asphalt overlay.

Blow-ups are typically caused by high temperature and incompressibles in the transverse joints. Hot temperatures cause the panels to expand and result in increased pavement stresses. Debris in the transverse joints, such as small rocks, or dirt, causes additional stress as the panels are pushed up against each other. With no place to move, the slabs eventually either "walk up" at one end or "blow out" at mid-panel from the increased stress. Older panels that were approximately 6m long contributed to this type of failure.

Excessive reflective cracking in crack and seat overlays can also lead to premature failure. This is primarily due to the loss of uniform support coupled with the slab's inability to carry the actual traffic loads. Conditions like these can lead to excessive reflection cracking of asphalt overlay.

Many times the repair option for these premature failures is limited to removing the slab and filling the hole with asphalt concrete. An asphalt concrete repair is typically selected due to the need to get traffic back on the pavement with the least possible disruption to traffic flow. However the disadvantages to this kind of strategy are:

- Achieving adequate compaction in a confined space, especially adjacent to the old existing concrete that will remain in place.
- Getting hot mix asphalt to quickly cool at a depth of 0.3 m.

In addition, such a repair strategy can further contribute to the deterioration rate of adjacent slabs by allowing excessive movement of the adjacent slab joints during routine traffic loading, large temperature changes, and freeze thaw cycles. Asphalt repairs in JPCP significantly reduce the aggregate interlock needed for load transfer. Reduced aggregate interlock results in higher stresses at the edges of the PCC pavement, adjacent to the AC patch, causing premature failure of the concrete and excessive faulting and roughness of the pavement surface.

The preferred repair option is to place RSC. Always consider the remaining life of the pavement when selecting the repair type, as well as the repair material. The use of RSC and load transfer devices will reduce the edge stresses in the older concrete slabs, as well as the repaired area, resulting in a better long-term performance solution. If the construction window does not permit the use of RSC, use an AR-8,000 or AR-16,000 asphalt binder to stiffen the mix. Remember that asphalt concrete is a short-term slab repair strategy.

When using RSC to repair deteriorated AC over crack and seated concrete, use Lampblack in the mix. This darkens the concrete to be more aesthetically pleasing in areas with asphalt overlays. Remember to mark the location on the shoulder with a paddle identifying the PCC plug so that future jobs, especially recycling projects, are aware that there is PCC in this location.

Remember that emergency repairs with RSC need not be temporary in nature. With ever-increasing traffic-control and user costs, especially on heavily traveled freeways, RSC may very well be the most cost effective and longer lasting solution.

In emergency, there will likely be a short construction window, and it is recommended in all cases to cover RSC with plastic and plywood to insulate and speed cure.

NOTES

APPENDIX D LIST OF ACRONYMS

- AC – Asphalt Concrete
- ACPA – American Concrete Paving Association
- ASR – Alkali-Silica Reactivity
- ASTM – American Society for Testing and Materials
- CTB – Cement Treated Base
- CT – California Test
- CV – Cleanness Value
- CTM – California Test Method
- FWD – Falling Weight Deflectometer
- HQ – Headquarters
- JPCP – Jointed Plain Concrete Pavement
- LTE – Load Transfer Efficiency
- METS – Material Engineering and Testing Services
- NDT – Nondestructive Testing
- PCC – Portland Cement Concrete
- PCCP – Portland Cement Concrete Pavement
- QC – Quality Control
- RSC – Rapid Strength Concrete
- SSP – Standard Special Provisions

NOTES

APPENDIX E APPLICABLE STANDARDS

STANDARD SPECIFICATIONS

- Section 25: Aggregate Subbase
- Section 28: Lean Concrete Base
- Section 40: Portland Cement Concrete Pavement
- Section 42: Groove and Grind Pavement
- Section 68: Subsurface Drains
- Section 90: Portland Cement Concrete

STANDARD PLANS

- A35A: Portland Cement Concrete Pavement (Undoweled Transverse Joint)
- A35B: Portland Cement Concrete Pavement (Doweled Transverse Joint)
- A35C: Portland Cement Concrete Pavement Joint and End Anchor Details
- A35D: Dowel Bar Retrofit in Existing Concrete Pavement

STANDARD SPECIAL PROVISIONS

- SSP 40-010: Concrete Pavement (with Doweled Transverse Weakened Plane Joints)
- SSP 40-015: Retrofit Existing Concrete Pavement with Dowels at Transverse Joints
- SSP 40-020: Replace Concrete Pavement (Rapid Strength Concrete)
- SSP 40-030: Portland Cement Concrete Base
- SSP 41-150: Repair Spalled Joints
- SSP 41-151: Repair Spalled Joints (Polyester Grout)
- SSP 41-200: Seal Joint

NOTES